How and why I wrote a LaTeX package

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University College London

PhD Thesis

Efficient computation and applications of the Calderón projector

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supervised by

Prof. Erik Burman & Prof. Timo Betcke

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Software frameworks for integral equations in electromagnetic scattering based on Calderón identities

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ABSTRACT

In recent years there have been tremendous advances in the theoretical understanding of boundary integral equations for Maxwell problems. In particular, stable dual pairings of discretisation spaces have been developed that allow robust formulations of the preconditioned electric field, magnetic field and combined field integral equations. Within the BEM++ boundary element library we have developed implementations of these frameworks that allow an intuitive formulation of the typical Maxwell boundary integral formulations within a few lines of code. The basis for these developments is an efficient and robust implementation of Calderón identities together with a product algebra that hides and automates most technicalities involved in assembling Galerkin boundary integral equations. In this paper we demonstrate this framework and use it to derive very simple and robust software formulations of the standard preconditioned electric field, magnetic field and regularised combined field integral equations for Maxwell.

1. Introduction

The numerical simulation of electromagnetic wave scattering poses significant theoretical and computational challenges. Much effort in recent years has gone into the development of fast and robust boundary integral equation formulations to simulate a range of phenomena from the design and performance of antennas to radar scattering from large metallic objects.

While there have been a range of important theoretical advances in recent years for the development of robust preconditioned boundary integral formulations for Maxwell, the computational implementation remains a challenge. At University College London, as part of the BEM++ project [1] we have developed a number of easy to use Python-based open-source tools to explore and solve Maxwell problems based on preconditioned electric field (EFIE), magnetic field (MFIE) and combined field (CFIE) integral equation formulations. In this paper, we give an overview of these developments, present simple example codes and discuss the underlying implementation. The goal is to make advanced integral equation solvers for Maxwell available to non-specialised users without requiring significant knowledge in the design and implementation of these methods.

In particular, we consider the following formulation of electromagnetic scattering from a perfectly conducting object. Let $\Omega^- \subset \mathbb{R}^3$ be a bounded domain with boundary Γ and denote by $\Omega^+ = \mathbb{R}^3 \setminus \overline{\Omega^-}$ its complement. Let $\boldsymbol{\nu}$ be the exterior normal vector on Γ pointing into Ω^+ as shown in Fig. 1.

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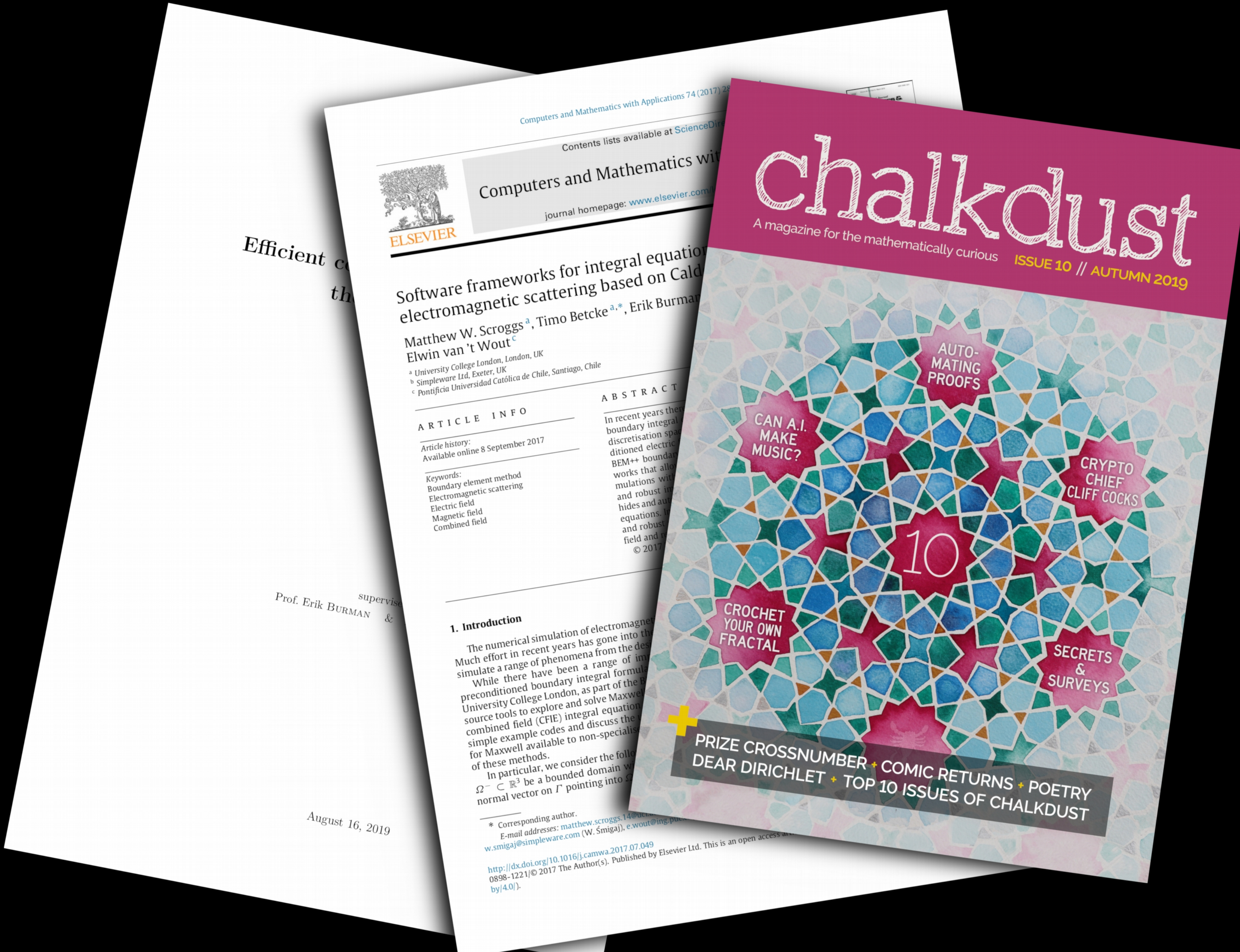
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ABSTRACT
1. Introduction
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$$\pi = 4$$

$$\int_0^{\frac{\pi}{2}} \frac{\sin x}{2\cos x}\,\mathrm{d}x = \left[-\frac{\ln|\cos x|}{2}\right]_0^{\frac{\pi}{2}}$$
$$= \left(-\tfrac{1}{2}\ln 0\right) - \left(-\tfrac{1}{2}\ln 1\right)$$
$$= \infty$$

$$\nabla f = \begin{pmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \\ \frac{\partial f}{\partial z} \end{pmatrix}$$

$$\mathrm{e}^{\mathrm{i}\pi} - 1 = -2$$

$$\sin(x+y) = \sin(x) + \sin(y)$$

$$\sum_{i=1}^{n} i > -\frac{1}{12}$$

```
\documentclass[preprint,12pt]{elsarticle}

\usepackage{amssymb}
\usepackage{amsthm}

\usepackage{bm}
\usepackage{upgreek}
\usepackage{amsmath}
\usepackage{comment}
\usepackage{amsfonts}
\usepackage{graphicx}
\usepackage{epstopdf}
\usepackage{algorithmic}
\usepackage[T1]{fontenc}
\usepackage{textcomp}
\usepackage{listings}
\usepackage{hyperref}
\usepackage{subcaption}
\lstset{upquote=true,
frame=single}

\usepackage{tikz}
\usepackage[utf8]{inputenc}
```

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\usepackage{hyperref}
\usepackage{subcaption}
\lstset{upquote=true,
frame=single}

\usepackage{tikz}
\usepackage[utf8]{inputenc}
```

In what follows we need the average
$\average{\cdot}$, and jump, $\jump{\cdot}$ of these tra
defined as \begin{align}
\average{\B{\gamma}_*}\B{f}&:=\frac12(\B{\gamma}_*\exter
+\B{\gamma}_*\interior \B{f}),&
\jump{\B{\gamma}_*}\B{f}&:=\B{\gamma}_*\exterior \B{f}-\
gamma}_*\interior \B{f}.
\end{align}
Let
$\B{L}^2_\textup{t}(\Gamma)$, defined by
\begin{equation}
\B{L}^2_\textup{t}(\Gamma):=\{\B{u}\in\B{L}^2(\Gamma):\B
bnu=0\},
\end{equation}
be the space of square integrable tangential functions.
We define the tangential trace space, $\B{H}_\times^{1/2
$, as in \cite[definition 1]{BuffaHiptmair} by
\begin{equation}\B{H}_\times^{1/2}(\Gamma):=\gtint(\B{H
interior))=\left\{\gtint\B{u}:\B{u}\in\B{H}^1(\Omega\int
right\}.\end{equation}
The dual of this space with respect to the antisymmetric
\begin{align}
\left\langle\B{a},\B{b}\right\rangle_{\tau}&:=
\int_\Gamma\B{a}\cdot(\bnu\times\B{b}),&\text{ for }\B{a
in\B{L}^2_\textup{t}(\Gamma).\label{eq:antisymmetric}

`\frac{a}{b}`

`\frac{a}{b}` $$\frac{a}{b}$$

```
\frac{a}{b}
```

$$\frac{a}{b}$$

```
\vec{a}
```

`\frac{a}{b}`	$\frac{a}{b}$
`\vec{a}`	$\vec{a}$

`\frac{a}{b}`	$\frac{a}{b}$
`\vec{a}`	$\vec{a}$
`\mathbf{a}`	

`\frac{a}{b}`	$\frac{a}{b}$
`\vec{a}`	$\vec{a}$
`\mathbf{a}`	$\mathbf{a}$

`\frac{a}{b}`	$\frac{a}{b}$
`\vec{a}`	$\vec{a}$
`\mathbf{a}`	$\mathbf{a}$
`\hat{a}`	

`\frac{a}{b}`	$\frac{a}{b}$
`\vec{a}`	$\vec{a}$
`\mathbf{a}`	$\mathbf{a}$
`\hat{a}`	$\hat{a}$



You know the \hat command in LaTeX?


You know the \ha
command in LaT
Of horse I do.


You know the \ha
command in LaT
Of horse I
Wouldn't it be funny if there was a LaTeX package that changed it so it put actual hats on things?


You know the \ha
command in LaT
Of horse I
Wouldn't it be funny if there was a LaTeX package that changed it so it put actual hats on things?
(!)

```
\documentclass{article}
```

$$\hat{a}$$

$$\hat{b}$$

$$\hat{c}$$

```
\documentclass{article}
\usepackage{realhats}
\begin{document}
$$\hat{a}$$
$$\hat{b}$$
$$\hat{c}$$
\end{document}
```

$$\hat{a}$$

$$\hat{b}$$

$$\hat{c}$$

```
\documentclass{article}
\usepackage{realhats}
\begin{document}
$$\hat{a}$$
$$\hat{b}$$
$$\hat{c}$$
\end{document}
```

Upload to the Comprehensive TEX Archive Network

If you want to upload a new version of a package to CTAN you can start the upload from the package's page. Then several fields will be pre-filled. Even more is pre-filled if you are logged in.

To get ready for uploading please read the hints at How can I **upload** a package? and some more details at Upload addendum.

The required fields are clearly marked like this sentence*. The form complains if a required field is missing.

New package | Package update

Provide a few bits of information that will help us to categorize the package

Name of your contribution*

This value corresponds to the name of the package in the TEX Catalogue. It must consist of ASCII characters only. It should start with a letter and may contain only letters, digits or the underscore.

Version*

Specify a meaningful version like 1.2 or 2.3.4. A release date in the form YYYY-MM-DD can be used as a fall-back in case you do not have a proper version number. Please consider Semantic Versioning as widely in software engineering.

Maintainer*

These are the names of the authors or maintainers. These names will be published with the package. Several names are separated by a semicolon (;).

Your name

Re: CTAN Upload: realhats • Erik Braun 04/02/2019, 11:55

Re: CTAN Upload: realhats • Erik Braun 04/02/2019, 11:55

"Your package realhats has been rejected because..."

Re: CTAN Upload: realhats • Erik Braun 04/02/2019, 11:55

“Your package realhats has been rejected because...”

“Please stop uploading jokes to CTAN.”

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"Please stop uploading jokes to CTAN."

"You have been banned from CTAN."

Re: CTAN Upload: realhats • Erik Braun 04/02/2019, 11:55

“I am proud to install this important package on CTAN.”

“The new package has been installed on our central server and will be announced about 24 hours later.”

Rolf Niepraschk submitted an update to the

xltabular

package.

Version number: 0.2b 2019-01-30
License type: lppl1.3

Summary description: Longtable support with possible X-column specifier

Announcement text:

Compatibility with package cleveref

The package's Catalogue entry can be viewed at
http://www.ctan.org/pkg/xltabular

The package's files themselves can be inspected at
http://mirror.ctan.org/macros/latex/contrib/xltabular

Thanks for the upload.

For the CTAN Team
Erik Braun

Matthew Scroggs submitted the

realhats

package.

Version number: 1.0
License type: mit

Summary description: Put real hats on symbols instead of ^

Announcement text:

This TeX package allows to replace the ^ hats above your unit vectors with pictures of actual hats

----

The package's Catalogue entry can be viewed at
http://www.ctan.org/pkg/realhats

The package's files themselves can be inspected at
http://mirror.ctan.org/macros/latex/contrib/realhats

Thanks for the upload.

For the CTAN Team
Erik Braun

4D Geometry

4D Geometry

$x \quad y \quad z$

4D Geometry

$x \quad y \quad z \quad a$

4D Geometry

$x \quad y \quad z \quad v$

4D Geometry

x y z v

4D Geometry

x y z v

Labelling equations

Labelling equations

$$x^3 + y^3 = z^3. \tag{$*$}$$

Equation $(*)$ is...

Labelling equations

$$x^3 + y^3 = z^3, \tag{$*$}$$

$$x^n + y^n = z^n. \tag{$*$}$$

Equation $(*)$ is...

Labelling equations

$$x^3 + y^3 = z^3, \tag{$*$}$$

$$x^n + y^n = z^n. \tag{$*$}$$

Equation $(*)$ is...

$$x^3 + y^3 = z^3, \tag{$*$}$$

$$x^n + y^n = z^n. \tag{$*$}$$

Equation $(*)$ is...

Solving hard equations

Solving hard equations

$$\overline{\hat{f}} + \hat{\dot{f}} = 1$$

Solving hard equations

$$\hat{\bar{f}} + \hat{\dot{f}} = 1$$

$$\overset{🎩}{f} + \overset{🎩}{f} = 1$$

Solving hard equations

$$\hat{\bar{f}} + \hat{\dot{f}} = 1$$

$$\overset{\text{🎩}}{f} + \overset{\text{🎩}}{f} = 1$$

$$2\overset{\text{🎩}}{f} = 1$$

Solving hard equations

$$\hat{\bar{f}} + \hat{\dot{f}} = 1$$

$$\overset{🎩}{f} + \overset{🎩}{f} = 1$$

$$2\overset{🎩}{f} = 1$$

$$\overset{🎩}{f} = \frac{1}{2}$$

Thanks for listening!

Matthew Scroggs

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